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Modeling Agile Software Maintenance Process Using Analytical Theory of Project Investment

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Abstract

A new modeling approach to analyze the impact of schedule pressure on the economic effectiveness of agile maintenance process is presented in this paper. Based on a causal loop diagram the authors developed earlier and the analytical theory of project investment, this paper analyzed the effect of schedule pressure on the economic effectiveness. Preliminary results show that maintenance effectiveness is low when schedule pressure is high, and is high when schedule pressure is low.

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Keywors: agile development methedology; software engineering; simulation; system dynamics; analytical theory of project investment

1. Introduction

Agile development methodology [1,2] is gaining popularity with software developers. Schedule pressure has been identified as important factor on the performance of project teams [3]. Yet, to our best knowledge, there has been few attempt to model the effect of schedule pressure on the economic effectiveness of agile software projects. Nan and Harter's [4] study is the first attempt to link schedule pressure to the performance of software development projects. This study applies the Analytical Theory of Project Investment [5-7] to model the effect of schedule pressure on the economic effectiveness of an agile maintenance process for software development based on the Authors' earlier work in [8,9].

Next, the causal loop diagram of a specific agile software maintenance process, which is going to be modeled in this study, is introduced. Then, the analytical theory of project investment is introduced and applied to the agile maintenance process. Finally, the results are summed up and conclusions drawn.

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2. An agile maintenance process

To analyze the economic effectiveness of agile methodologies, we use an agile maintenance process Critical Feature Method (CFMethed)[8] as an example. CFMethod is a light weight maintenance methodology for small and medium size enterprises (SMEs). CFMethod is designed to effectively handle urgent change requests. There are a number of phases in the maintenance process. We take the exploration phase as an example to analyze the economic effectiveness of the software development activities. The factors that influence the activities in exploration phase are identified in the causal loop diagram of the system dynamics approach [10] shown below. As shown in Fig. 1, schedule pressure has impact on a number of factors that will ultimately affect project outcomes.

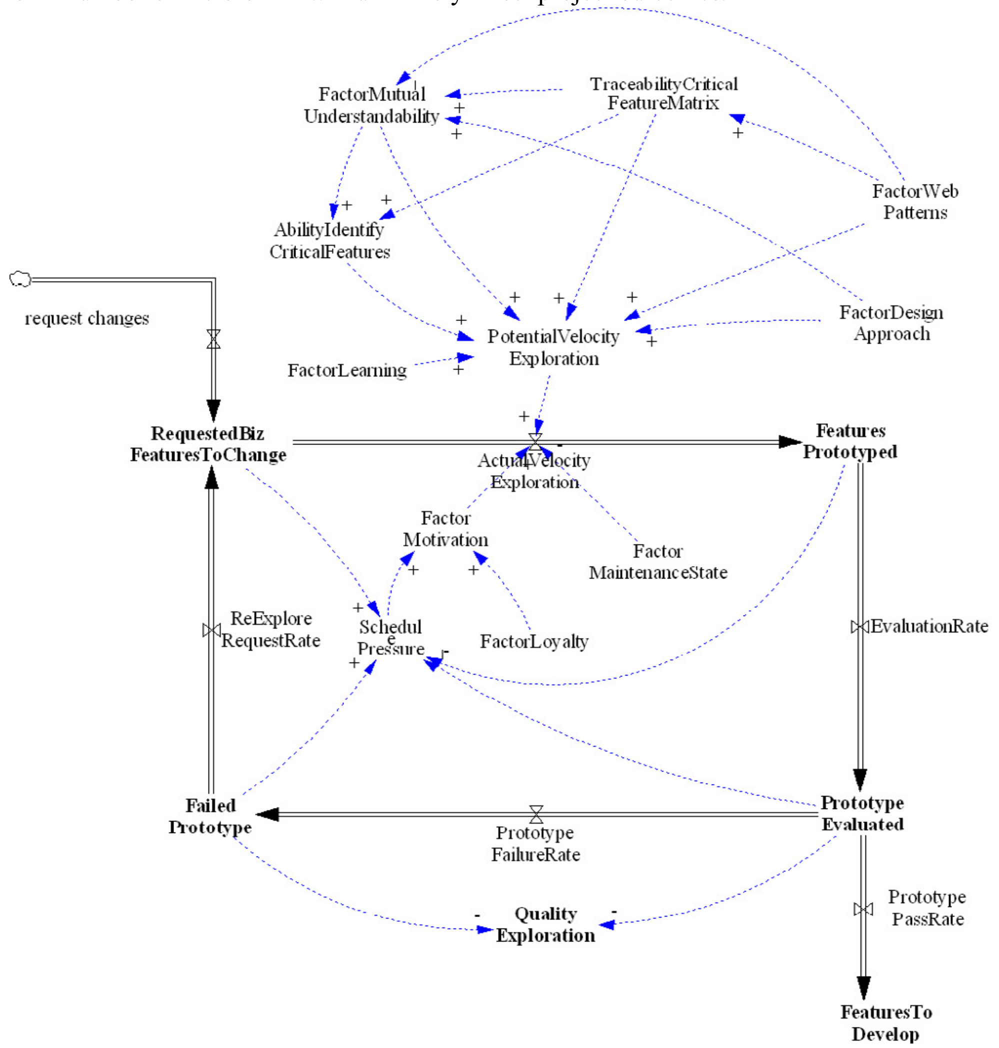

Fig. 1. Maintenance exploration phase and impact factors

3. The analytical theory of project investment

The Analytical Theory of Project Investment [5-7] is briefly introduced below applied in this study to analyze the economic effectiveness of the agile maintenance methodology.

Let S represents the economic value of a project, r, the rate of return and σ, the rate of uncertainty of the economic value of the underlying asset. The incremental value of S can be represented by a lognormal process:

$$\frac{dS}{S} = rdt + \sigma dz \tag{1}$$

The total project costs can be divided into two components: a pre-committed project cost K, and a variable cost C. The pre-committed project cost component K is defined as the project cost incurred before the start of the project. The project variable cost C refers to the project costs that have been incurred after the project has started. From the Feymann-Kac formula [11], the variable cost C, as a function of the economic value of the project S, satisfies the following equation:

$$\frac{\partial C}{\partial t} = rS\frac{\partial C}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 C}{\partial S^2} - rC \tag{2}$$

with the initial condition:

$$C(S,0) = \max(S-K,0) \tag{3}$$

When the duration of a project is T, the solution of (2) with (3) is as the following equation:

$$C = SN(d_1) - Ke^{-rT}N(d_2) \tag{4}$$

where

$$d_1 = \frac{\ln(S/K) + (r+\sigma^2/2)T}{\sigma\sqrt{T}}$$
$$d_2 = \frac{\ln(S/K) + (r-\sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \tag{5}$$

The function $N(x)$ is the cumulative probability distribution function for a standardized normal random variable. Although Eq. (4) takes the same form as the well-known Black-Scholes [12] formula for European call options, the meaning of the parameters and the implications of the equations are very different. Eq. (4) provides an analytical relation among the economic value S of a project, pre-committed project cost component K, the project cost C, duration of the project T, uncertainty level σ in the project, and the risk-free interest rate r.

4. Analyzing project impacts using the analytical theory of project investment

To analyze the economic effectiveness of the agile maintenance process CFMethod, we define the process economic effectiveness *MtnEff* as the ratio of the economic value of the project S over the pre-committed project cost K pluses the variable cost C. The definition *MtnEff* is presented as in the following equation:

$$MtnEff = \frac{S}{C+K} = \frac{S}{SN(d_1) - Ke^{-rT}N(d_2) + K} \tag{6}$$

where d_1 and d_2 are as Eq. (5).

From the diagram in Fig. 1, we take the influence factor “schedule pressure” as an example.

In the exploration phase of the maintenance process, developers typically face schedule pressure in the form of tight deadlines. In this study, the simulated project is a web maintenance project based on a process called Critical Feature Method introduced in section two. The key assumption is that when schedule pressure increases, through impacting other factors as shown in Fig. 1, the uncertainty (σ) of project value increases. Therefore, by increasing the maintenance duration (T), the schedule pressure decreases. As a result, the uncertainty level (σ) of the maintenance phase decreases. In contrast, when project duration is reduced, schedule pressure increases and thus the uncertainty level.

As illustrated in Fig. 2, we have calculated and plotted three curves of maintenance effectiveness under high, medium and low schedule pressure situations, respectively. The bottom curve is the situation where the impact of schedule pressure on the uncertainty level of the project is high. As shown in the curve, the effectiveness decreases when duration increases. The middle curve shows a similar trend for the effectiveness. The uncertainty level here is lower than the bottom curve. Similarly, the top curve shows the effectiveness decreases when duration increases.

Comparing the three curves, Fig. 2 shows that the effectiveness is highest when schedule pressure is low.

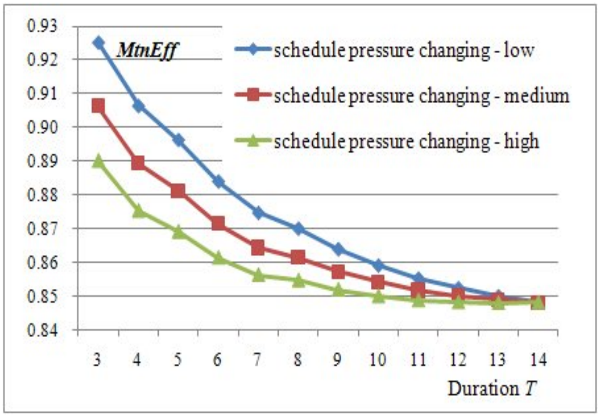

Fig. 2. Impact of schedule pressure on maintenance effectiveness.

5. Conclusion and future research

By applying the analytical theory of project investment, we have analyzed the impact of schedule pressure on the economic effectiveness of an agile maintenance method. The economic effectiveness of the process is defined using the theory of the analytical economic model. The simulation results show that

The maintenance effectiveness is high when schedule pressure is low, and, low when schedule pressure is high.

This finding resonates with one of the best practices for extreme programming [13] that limits working hours to 40 hours per week. As schedule pressure increases, crashing is likely to happen which could lead to errors and rework, thus delays and cost overrun.

This research provides a new approach in software engineering: quantifying software development processes using analytical modeling. Further research would be extending this analytical approach to software development life cycle and associated economic activities.

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